FACET: Future ATM Concepts Evaluation Tool

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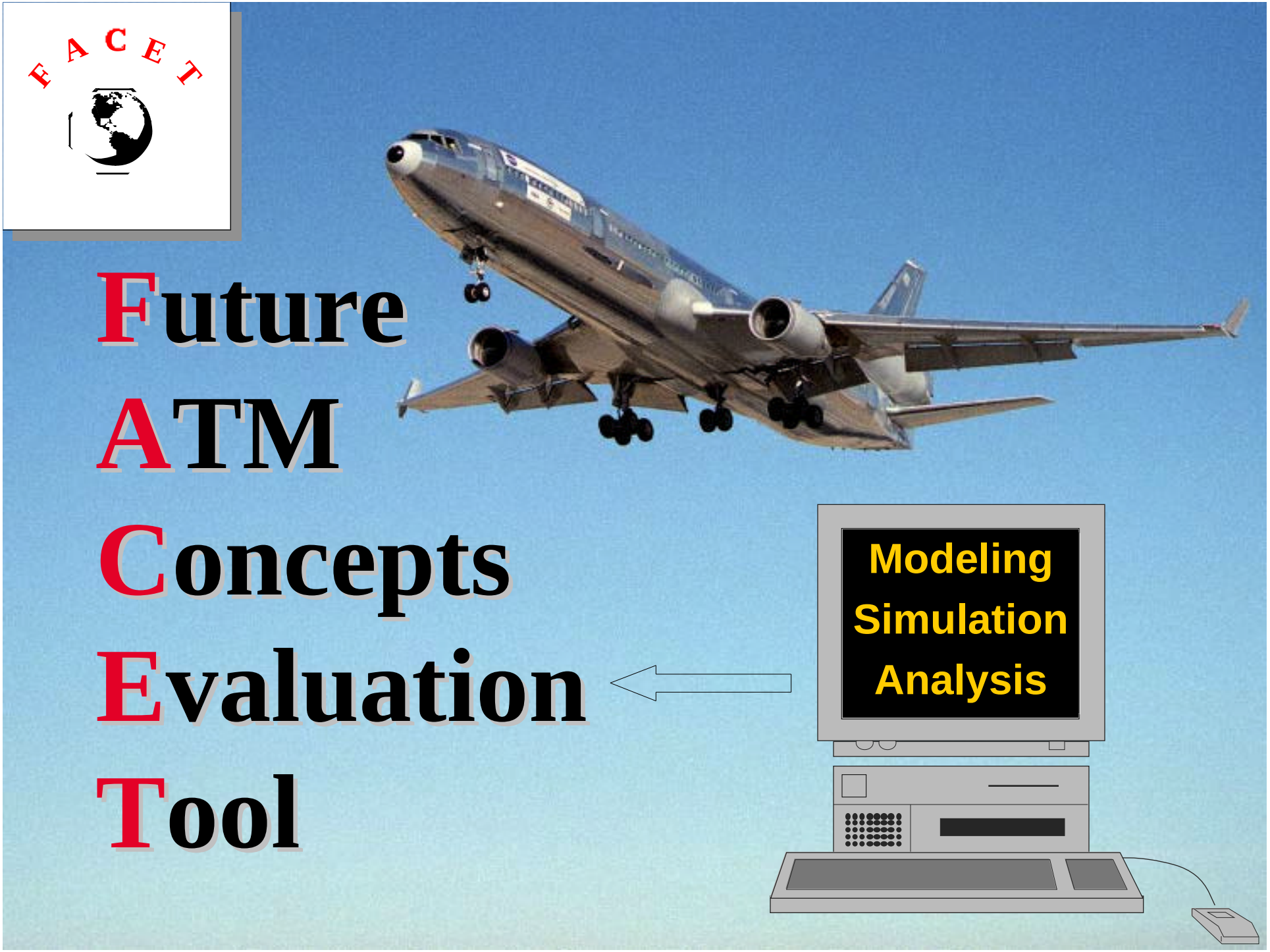

FACET
Future
ATM
Concepts
Evaluation
Tool
Modeling
Simulation
Analysis

Outline

- Introduction to FACET
- Major Functionalities and Features
- Graphical User Interface
- Applications
  - Airborne Self-Separation for Free Flight
  - Benefits of CTAS Direct-To Tool
  - Advanced Traffic Flow Management
  - Space Vehicle Operations in the Airspace System
  - Visualization of Air Traffic Data
- Summary

Introduction to FACET

- Simulation tool for exploring advanced ATM concepts
  - Flexible environment for rapid prototyping of new ATM concepts
  - Can be used for both interactive and off-line studies
  - Interface with ETMS data (track and flight plan information)
  - Weather data processing

- Key Attributes
  - Models airspace operations at U.S. national level (~ 5,000 aircraft)
  - Modular architecture for flexibility
  - Software written in “C” and “Java” programming languages
    - » Easily adaptable to different computer platforms
    - » Runs on Sun, SGI, PC and Macintosh computers
  - Hierarchically compatible with CTAS in scope and fidelity

FACET complements CTAS

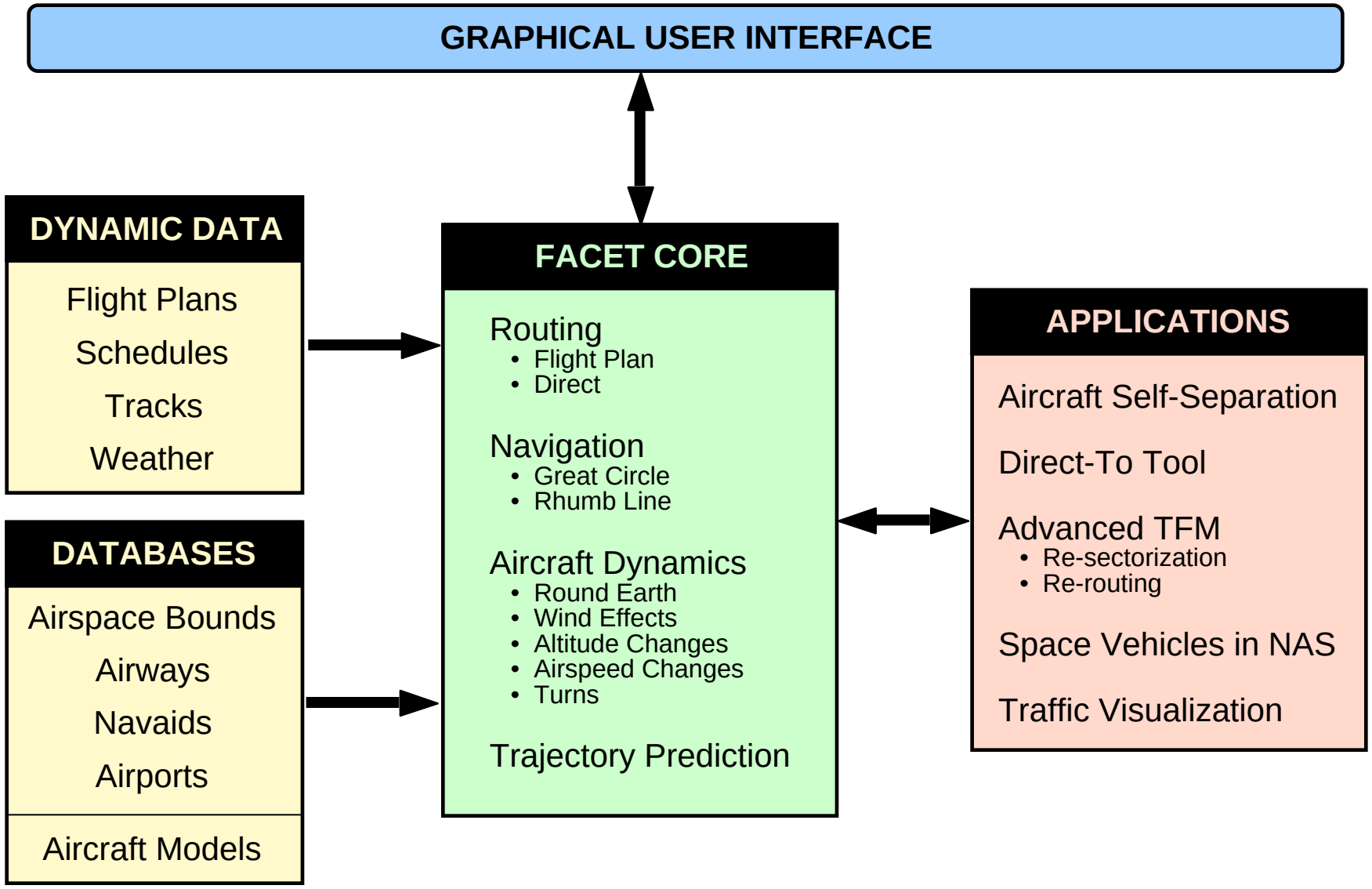
Feature	FACET	CTAS
Trajectory Modeling	Simplified 3-DOF model (climb rate/speed tables)	Point-mass 3-DOF model (thrust and drag models)
Airspace Modeling	ARTCCs only	ARTCC and TRACON
Flight Plan Processing	Yes	Yes
Weather Modeling	RUC-2	RUC-2
Modeling Scope	National Airspace (~ 5,000 aircraft)	Center Airspace (~ 500 aircraft)
Computer Platform	Single desktop computer (e.g., Sun, SGI, Mac, PC)	8 to 10 networked Sun workstations

Principal Functionalities

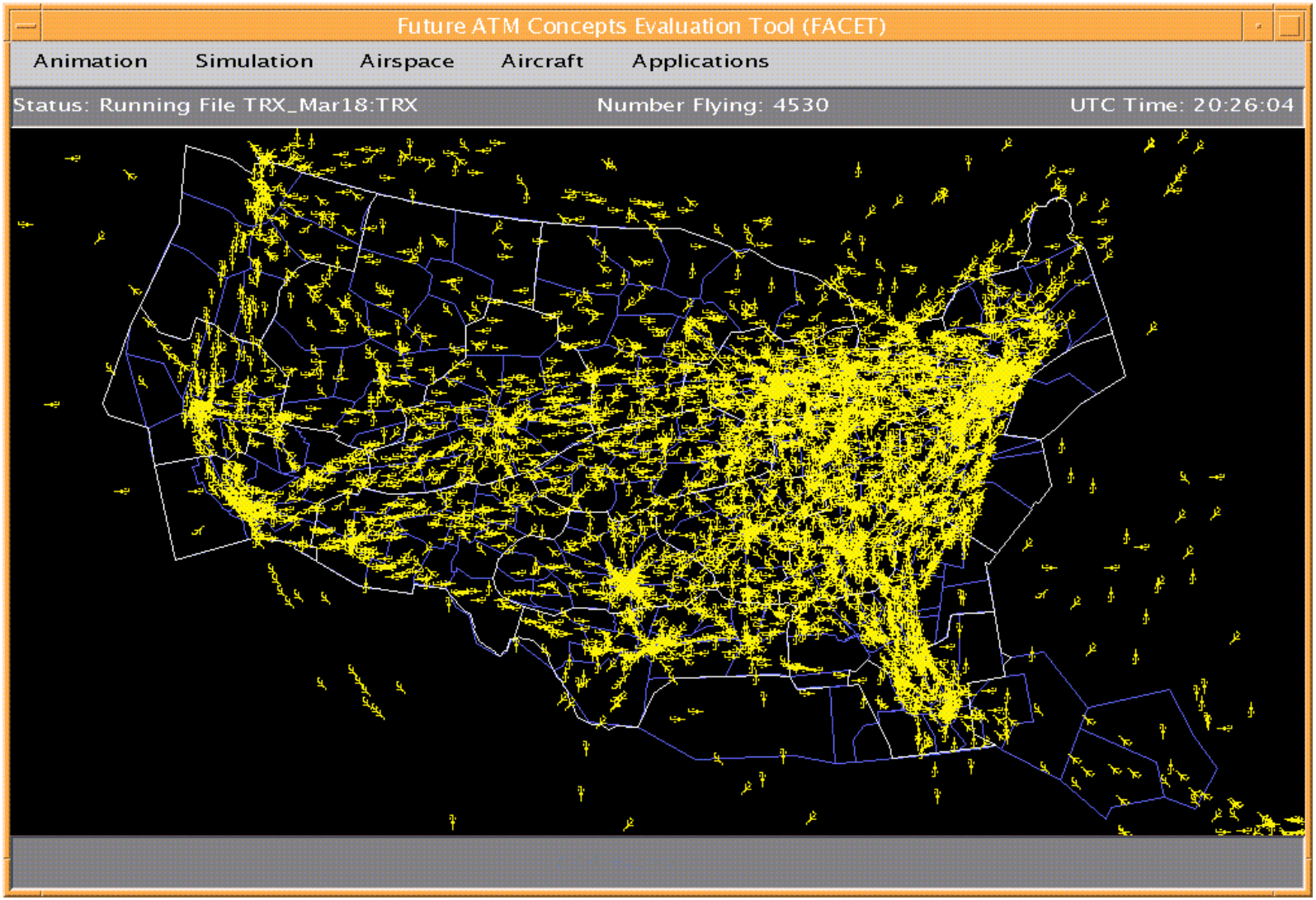
- Modeling of en route airspace over the entire continental U.S.
  - Center and sector boundaries
  - Special Use Airspace boundaries
  - Jet Routes and Victor Airways
  - Locations of navaids and airports

- 4-D trajectory modeling capabilities
  - Fly flight-plan routes or direct (great circle) routes over round earth
  - Climb/descent performance models for 66 aircraft types, mapped to over 500 aircraft types
  - Dynamic models for turns and acceleration/deceleration
  - Weather models (e.g., winds, convective cells)
  - Ability to add new class of vehicles (e.g., space launch vehicles)

Schematic Overview of FACET



Graphical User Interface



Applications

- Airborne Self-Separation for Free Flight
- Benefits Study of CTAS Direct-To Tool
- Advanced Traffic Flow Management (TFM)
- Space Launch Vehicle Operations in the Airspace System
- Visualization of Air Traffic Data

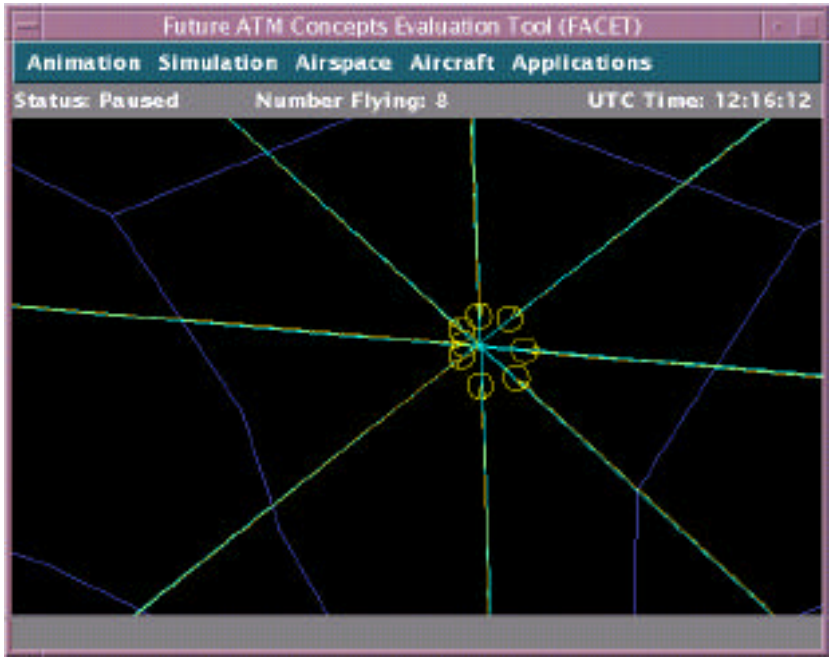
Airborne Self-Separation (1 of 2)

- Distributed Air/Ground Traffic Management (DAG-TM) is a detailed concept of operations for mature Free Flight
  - DAG-TM concept developed by a team of NASA researchers
  - Free Maneuvering is a key element of DAG-TM
  - Airborne self-separation is necessary to enable Free Maneuvering

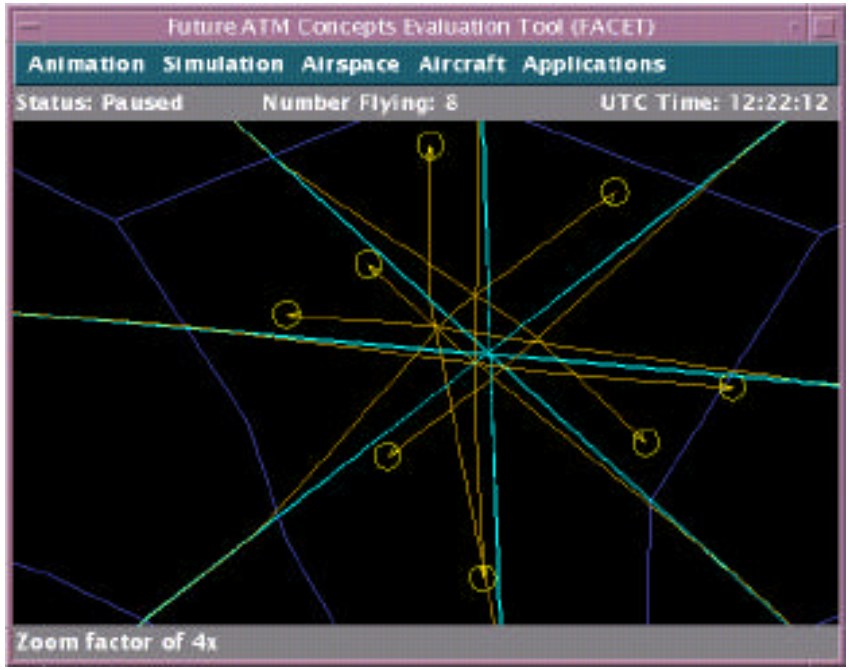
- Conducted feasibility evaluation of airborne separation assurance for free flight
  - System performance measured by path length and flight time
  - System stability measured by trajectory interruptions
  - Two CD&R schemes implemented in FACET
    - » Geometric Optimization approach (developed at NASA-Ames)
    - » Modified Potential Field approach (developed at MIT Lincoln Lab)

Airborne Self-Separation (2 of 2)

Conflict Detection and Resolution (CD&R)
using Geometric Optimization approach



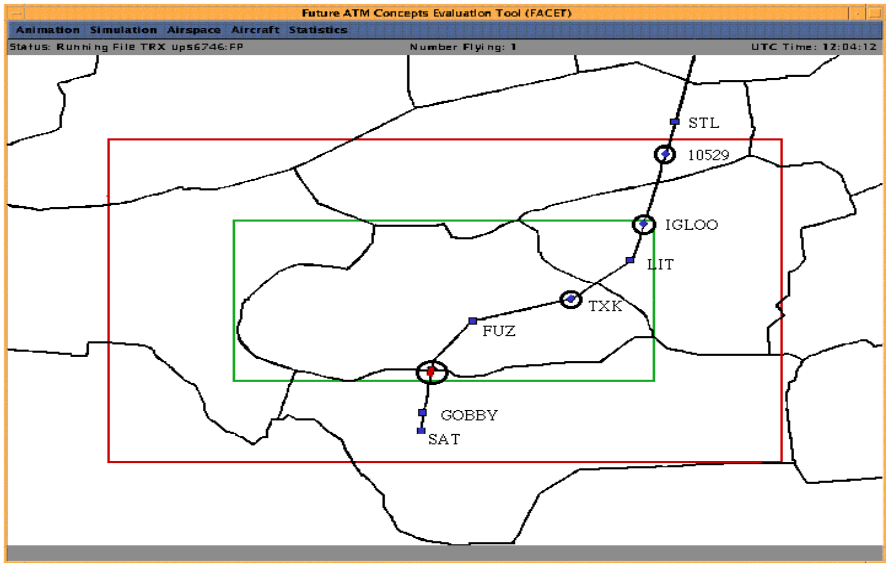
Test Scenario without CD&R



Test Scenario with CD&R

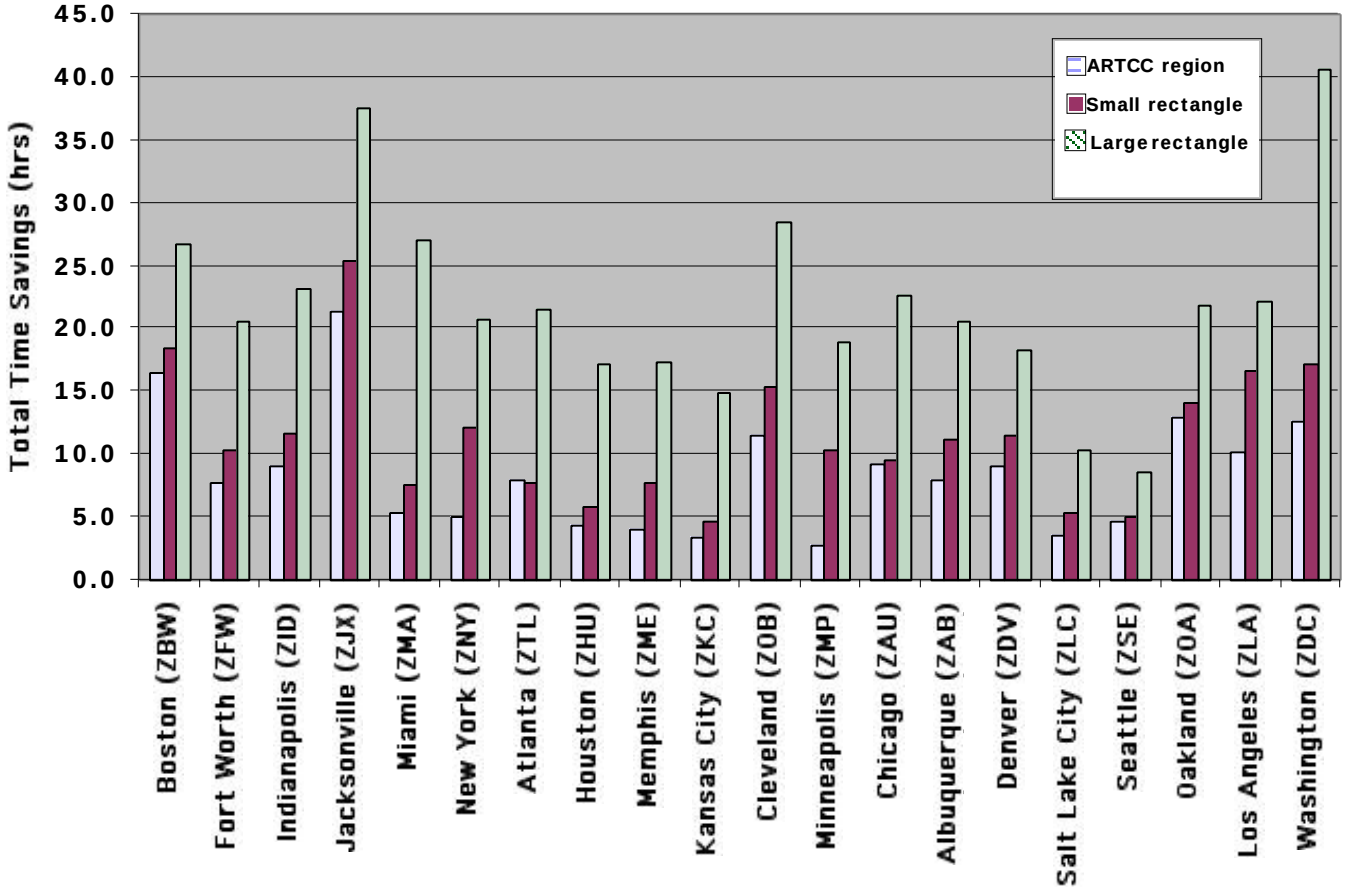
Benefits of Direct-To Tool (1 of 2)

- Direct-To is part of the CTAS family of controller DSTs
  - Identifies flight plan "short-cuts" that provide time savings
- Prototype of Direct-To tool implemented in FACET
  - Calibrated with CTAS data for Forth Worth Center
- 24-hr ETMS data set processed in FACET for 20 Centers in the U.S., using various windows
- Compiled results for flight time savings



Benefits of Direct-To Tool *(2 of 2)*

Total Savings estimated at $107 Million/Year
(169 flight hours per day, at an operating cost of $29/minute)



Advanced TFM Techniques *(1 of 3)*

- An important TFM function is to satisfy airspace constraints (weather cells, Special Use Airspace, congested sectors) without exceeding controller workload thresholds

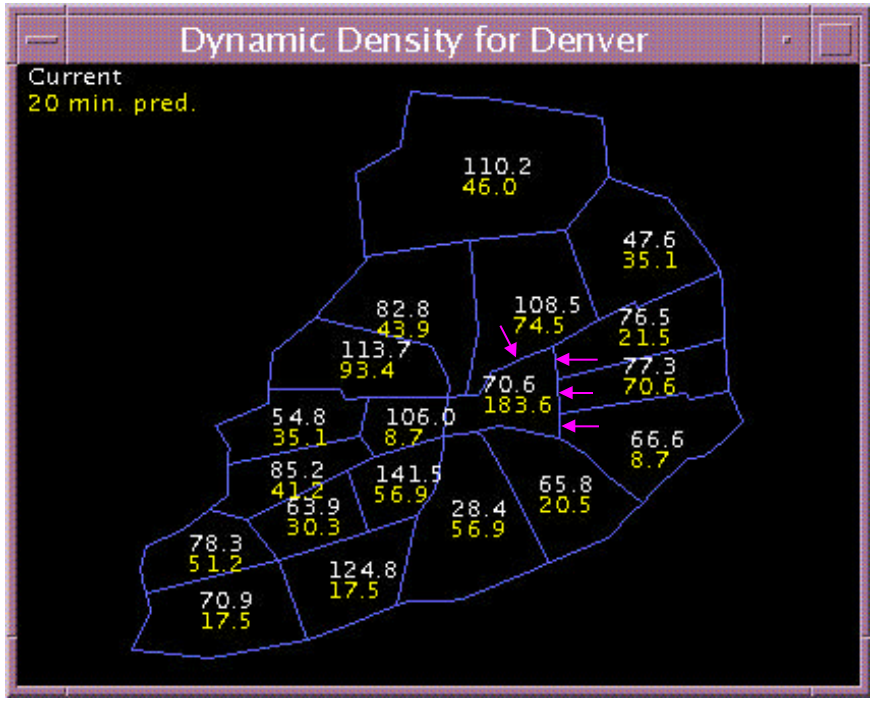
- Dynamic Density
  - Controller workload is a function of Airspace Complexity
    - » Depends on: number of aircraft, geometry of trajectories, aircraft mix, etc.
  - Dynamic Density is a measure of Airspace Complexity
    - » A Dynamic Density measure has been implemented in FACET
    - » This measure was derived from actual controller workload and air traffic data recorded during a NASA field test

- Airspace re-design and aircraft re-routing techniques, utilizing dynamic density, are being developed and tested

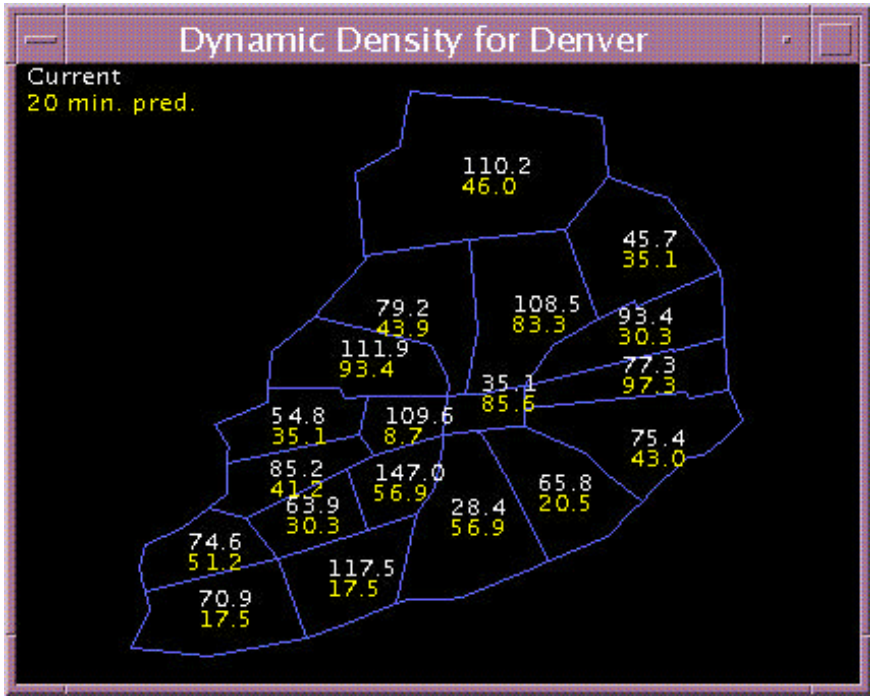
Advanced TFM Techniques (2 of 3)

Reduce predicted sector overload
by re-configuring sector boundaries

Before Re-sectorization

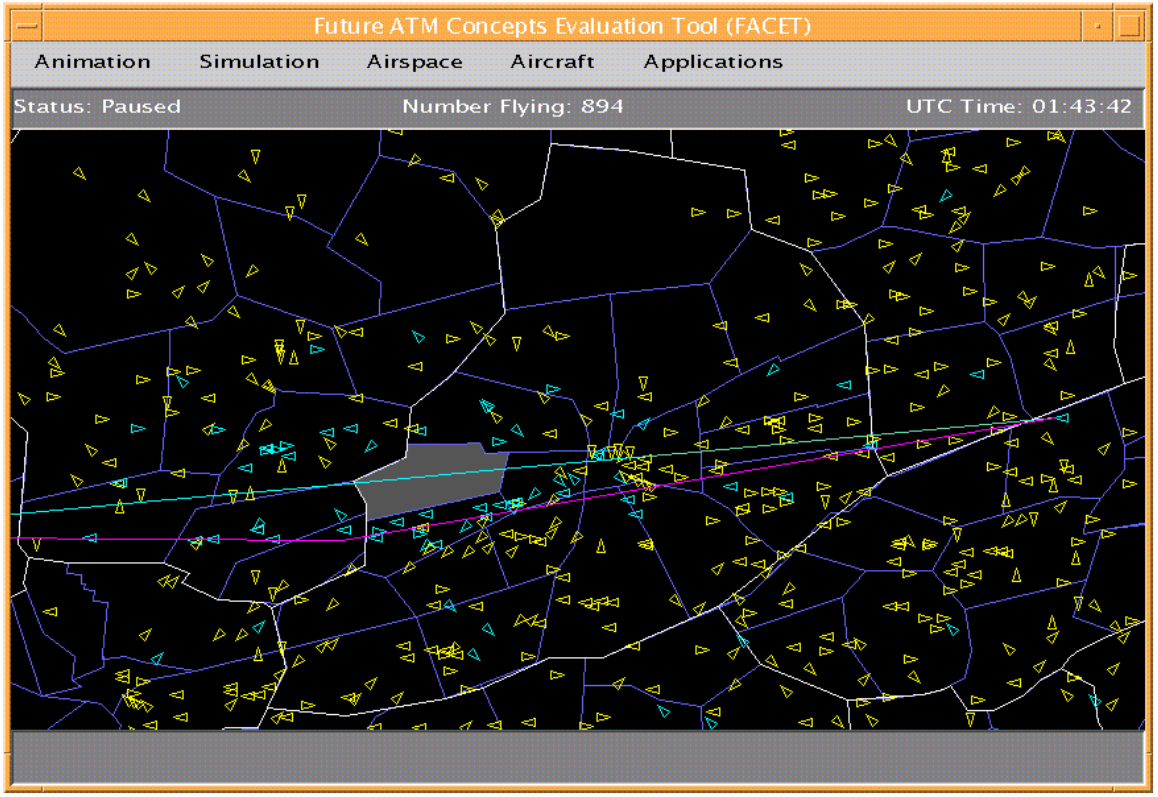


After Re-sectorization



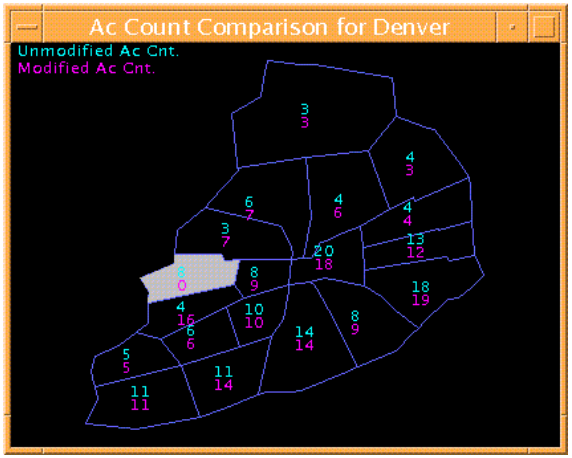
Advanced TFM Techniques (3 of 3)

Satisfy airspace restrictions by re-routing aircraft



Re-routing around a region of airspace

Aircraft counts



Space Vehicle Operations (1 of 2)

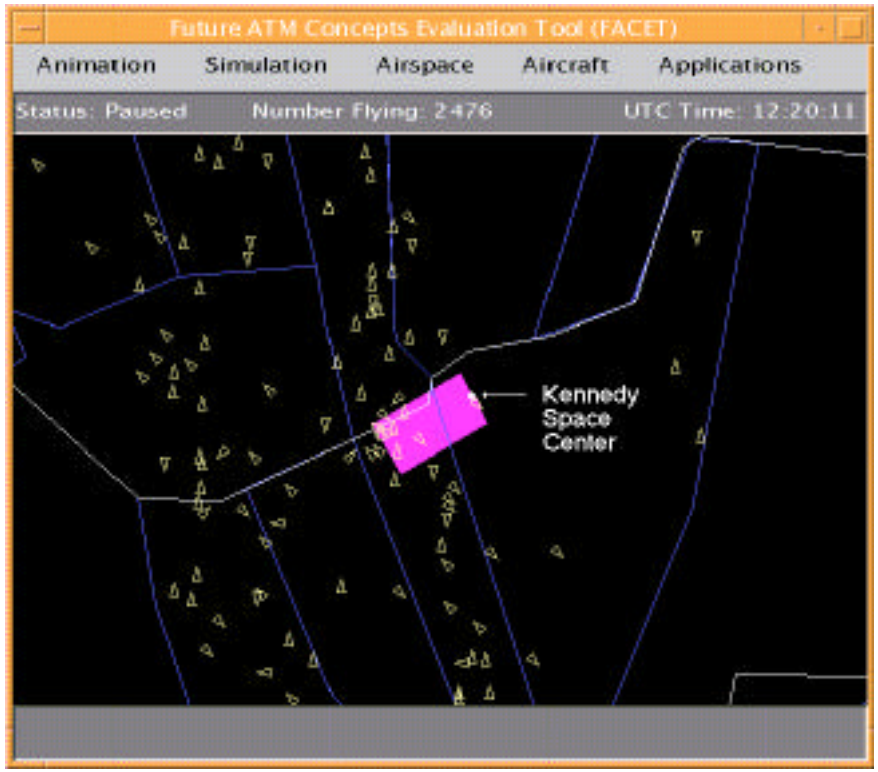
- Interaction of Air and Space Traffic
  - Space vehicles operate in the U.S. NAS during re-entry and/or ascent
  - Space vehicle operations projected to increase significantly
    - » Future spaceports may be located inland (away from coastlines)
  - Large volumes of Special Use Airspace (SUA) reserved for operations
  - Need to study interactions between air and space vehicle operations
    - » Shared airspace usage for all vehicle classes
    - » Dynamic negotiation/allocation of space traffic corridors
    - » Coordinate spaceport operations with air traffic operations

- Preliminary studies are underway
  - Trajectory modeling of space vehicles
  - Initiated study on interaction of air and space traffic

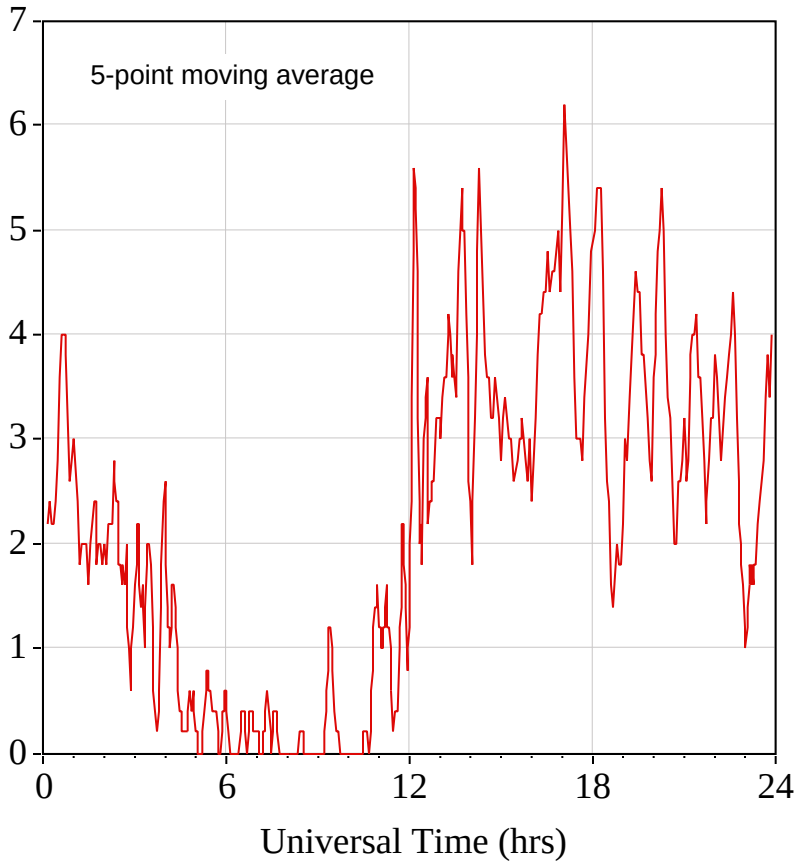
Space Vehicle Operations (2 of 2)

Interaction of Air and Space Vehicle Traffic

Example of RLV Airspace Corridor



Aircraft Count in RLV Corridor



Summary

- Future ATM Concepts Evaluation Tool (FACET) is a flexible environment for rapid prototyping and evaluation of advanced ATM concepts

- Key Features
  - System-wide modeling of airspace and 4-D trajectories
  - Modular, platform-independent architecture

- Prototypes of several advanced ATM concepts are under development and evaluation in FACET

- Evolution of FACET will be guided by NASA's research needs